Development and Testing of a Refractory Millimeter-Wave Absorbent Heat Exchanger

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Central to the Millimeter-Wave Thermal Launch System (MTLS) is the millimeter-wave absorbent heat exchanger. We have developed metallic and ceramic variants, with the key challenge being the millimeter-wave absorbent coatings for each. The ceramic heat exchanger came to fruition first, demonstrating for the first time >1800 K peak surface temperatures under illumination by a 110 GHz Gaussian beam.

Absorption efficiencies of up to 80% are calculated for mullite heat exchanger tubes and up to 50% are calculated for alumina tubes. These are compared with estimates based on stratified layer and finite element analyses. The problem of how to connect the 1800 K end of the ceramic tubes to a graphite outlet manifold and nozzle is solved by press fitting, or by threading the ends of the ceramic tubes and screwing them into place. The problem of how to connect the ceramic tubes to a metallic or nylon inlet pipe is solved by using soft compliant PTFE and PVC tubes that accommodate thermal deformations of the ceramic tubes during startup and operation. We show the resulting heat exchangers in static tests using argon and helium as propellants.